

expected to trust out of my possession valuable preparations, which, if lost or injured, I might never be able to replace. But I am quite willing to give time and trouble to enable those who wish to make the "comparison of the actual specimens" for themselves, to do so, without any "verbal arguments" or "prolonged disputations."

If the so-called *Eozoon* be really an Organic structure, whether Foraminiferal or any thing else, it is time that it should be generally acknowledged as such. But if it can be shown to be a Mineral pseudomorph, I quite agree with Mr. Carter that the sooner it is exploded as a sham, the better it will be for Geology. I trust that my scientific career has given sufficient evidence of my having "loved truth better than system," to justify my assertion that I shall be quite ready to surrender it, if I can be proved to be mistaken (as I have been before now) by the examination of my own specimens, and that I shall even thank any one who will set me right. No one, however, of the many eminent scientific men who *have* examined and compared these specimens, has as yet pointed out to me any error in my interpretation of the appearances they present; and nearly all of them have expressed their unreserved acceptance of it.

XXXVII.—*On the Arrangement of Sponges.*

By Dr. J. E. GRAY, F.R.S. &c.

I PROPOSED an arrangement of sponges in the 'Proc. Zool. Soc.' 1867, p. 502, of which I suggested a modification in the 'Ann. & Mag. Nat. Hist.' 1868, i. p. 165, and 1872, ix. p. 440, and especially in a paper which I wrote on the division of the spicules of sponges into types (Ann. & Mag. Nat. Hist. 1873, xii. p. 203).

The continued study of the structure of sponges and of their spicules has induced me to propose an alteration in their arrangement, as a sequel to the last quoted paper, which I believe will make it more natural and facilitate their study.

I would divide the Porifera, or sponges, into four orders :—

Order I. ARENOSPONGIA (Ann. & Mag. Nat. Hist. 1872, ix. p. 448, enlarged). The sponges strengthened by particles of sand, fragments of spicules, and other siliceous bodies, which they collect from the sea.

Order II. THALASSOSPONGIA (Ann. & Mag. Nat. Hist. 1872,

ix. p. 446). The sponge olive, formed of a fleshy or horny skeleton, and strengthened by regular siliceous spicules which are secreted by it; ovisacs membranaceous, scattered in the substance of the sponge.

Order III. POTAMOSPONGIA (Ann. & Mag. Nat. Hist. 1872, ix. p. 461). The sponge green; skeleton strengthened by regular siliceous spicules; ovisacs cartilaginous, strengthened by fusiform or birotate siliceous spicules. (See the divisions proposed in the 'Annals' above quoted, p. 461.)

Order IV. CALCISPONGIA. The sponge strengthened by regular calcareous, generally three-rayed, spicules.

Order I. ARENOSPONGIA.

The sponges of this order, which vary in shape from being discoidal, massive, to dendroidal, are peculiar for collecting together the sand or fragments of spicules, which are abundant at the bottom of the sea, for the purpose of giving strength and consistence to their structure; and these answer the same purpose as the siliceous or calcareous spicules which are secreted by the other marine and freshwater sponges. The quantity of horny matter covering the sand, and the quantity of sand enclosed by it, are very different in the different species of these sponges. It sometimes forms a thick, fibrous, horny skeleton, with only a single layer of sand in the centre of the fibre; and in some species this sand is only found in the thicker part of the horny skeleton. In other species the sponge seems entirely formed of sand merely kept together by a thin coat of horny matter.

In the arrangement I proposed in 1867 I placed the sponges of this group in two families, Dysideidæ and Xenospongiadæ, placing the latter family in a subsection which I called sand sponges (Arenospongiadæ), and the other family with the Ceratospongia. But more mature consideration has induced me to increase the suborder Arenospongia and put them together; for it is a very important element in the economy of the animal that one family collects together the ready formed siliceous bodies, and the other secretes the siliceous or calcareous spicula by which the body of the sponge is strengthened.

This order consists of two families:—

1. Xenospongiadæ.

Sponges discoidal, strengthened with irregularly placed sand and fragments of spicules.

2. *Dysideidæ*.

Sponges massive or dendroidal, formed of fibres constituting a more or less thick coat to the more or less abundant sand or fragments of spicules contained in their centre.

Dysidea and *Halispongia*, Bowerbank, Proc. Zool. Soc. 1872, t. vi.

The *Xenospongiadae* are peculiar for having a series of very slender diverging filiform spicules on the circumference, and pencils of similar spicules on the mouth of the oscules on the upper surface of the disk, which appear very different from the spicules of other sponges both in structure and position; and I am not aware that they have been observed in *Dysideidæ*. Some of the calcareous sponges have the oscule similarly fringed or bearded.

Order II. THALASSOSPONGIA.

This is a very large and numerous group of sponges, characterized by their secreting the siliceous spicules by which their body is almost universally strengthened; but the number and form of the spicules very greatly vary in the different kinds. In some, as in the coral-sponges, the body is almost entirely formed of spicules which are united together by a deposit of siliceous matter on their surface, forming the whole into a hard siliceous coralloid body; in others the sponges merely form a horny skeleton, containing one or more series of spicules in its central line. I am inclined to place the genus *Spongia*, which is formed entirely of a horny skeleton without any spicules, as an aberrant or abnormal form of this order, though perhaps we may find, when the habit and structure of these bodies are more known, that some species of true sponges (*Spongia*) are aberrant sand-sponges which do not collect sand, and other species are aberrant spicular sponges that do not secrete spicules.

The *Thalassospongia* may be divided into various suborders according to the spicules which they secrete, and whether they secrete spicules of all, of one, or of two or more of the types of spicules which I described in the 'Ann. & Mag. Nat. Hist.' 1873, xii. p. 203.

The sponges are all provided with more or less abundant simple subcylindrical spicules, which may be regarded as the basis of their skeleton; but some have spicules of one or more of the other types added to them; and I am inclined to divide them into suborders according to the various types of spicules by which their body is strengthened; and they often have free

spicules scattered in the sarcode, which are generally of a small size and uniform shape, and are characteristic of each suborder. Thus they are hamate unilateral in the Hamispongia, sex-radiate in the Sexradiatospongia, and stellate multiradiate, in the form of spicular spherules, in the Quinqueradiate group.

In the division of the marine sponges, like other natural bodies, into suborders or types the characters of the orders given are those of the general mass of species belonging to it; but there occur genera or families that have most of the characters of the suborder or family but want the essential character of the group—as the genus *Spongia*, which belongs to the order Thalassospongia, but wants the characteristic siliceous spicules. In the same manner *Placospongia* has the spherical spicules of the quinqueradiate sponges, but appears to be without the quinqueradiate spicules; and the *Chondrilladæ* have the many-rayed spicules of the same suborder, but also want the five-rayed spicules—these groups being what Mr. MacLeay called “aberrant types.”

Suborder I. LEIOSPONGIA.

The sponges only strengthened by simple, elongate, sub-cylindrical, fusiform spicules, tapering at each end, or enlarged, club-shaped, or capitate at one or both ends. This suborder is without spicules of the sexradiate or quinqueradiate types, or the free spicules peculiar to each.

This suborder contains many species, and requires much study to make out its structure, which I am glad to say Mr. Carter is bestowing upon it.

It contains :—

1. The *Suberispongia*, which are massive, with inosculating areolar cavities terminating in a vent on the surface—as *Suberitidæ* and *Raphiophoridæ* ('Annals,' l. c. p. 447).
2. The *Keratospongia*, with a skeleton formed of reticulated horny fibres having one or more series of spicules in the central line—as *Chalinidæ*, *Phakelliadæ*, *Halichondriadæ*, and *Polymastidæ*.
3. The *Ophistospongia*, with a skeleton like the *Keratospongia*, but with diverging spicules on its outer surface—as *Ophistospongiadæ* ('Annals,' l. c. p. 447).

Suborder II. HAMISPONGIA (Ann. & Mag. Nat. Hist. 1872, ix. p. 448).

Sponges with unilateral spicules, which are curved at each end, and either subcylindrical or more or less expanded, in

addition to the fusiform, clavate, or capitate spicules of the former suborder.

This suborder consists of the family Esperiadæ (Proc. Zool. Soc. 1867, pp. 502, 532), except the genus *Carteria*, which proves to be a sexradiate sponge. Some genera have only the bihamate spicules; but in general they have bihamate and contorted spicules.

In the 'Ann. & Mag. Nat. Hist.' (l. c.) I divided this suborder into four families—Esperiadæ, Desmacidonidæ, Hamacanthidæ, and Gelliadæ.

Suborder III. SEXRADIATOSPONGIA.

Sponges with spicules of the sexradiate type, in combination with the simple spicules of the Leiospongia.

This suborder agrees with the Hexactinellidæ of Mr. Carter, so well described in the 'Ann. & Mag. Nat. Hist.' 1873, xii. p. 357, excluding the genus *Hyalonema*, and adding to it the genus *Carteria*, which Mr. Carter partly describes and figures under the name of *Hyalonema*.

In the paper in the 'Proc. Zool. Soc.' for 1867 I formed the order Coralliospongia, and in the 'Ann. & Mag. Nat. Hist.' 1872, ix. p. 447, I considered "the hexaradiate spicules the essential character of the order" (see p. 449). It has since been found to contain a series of sponges which belong to the quinquerradiate type and are placed separate by Mr. Carter, a correction which I gladly acknowledge and adopt.

The radiating spicules which form the skeleton of the body are frequently of large size, and are modified in form according to the position which they occupy in the body. The lateral rays in perfectly developed spicules are generally equal; but at other times one or more of the rays are only partially developed. The shaft or central axis is frequently elongate, much longer than the lateral rays; but when the spicules are on the surface of the sponge the outer end of the shaft is more or less imperfectly developed, sometimes reduced to a single tubercle, and the other end of the shaft on the inside of the sponge is frequently much lengthened. The two ends of the shaft are almost always simple; but the lateral rays, especially of the quinquerradiate type, are frequently forked.

The sexradiate spicules which are scattered in the sarcode, and consequently free from each other, are always of a much smaller size than the skeleton-spicules, and of uniform structure, and nearly all of the same size. Mr. Carter has named them *rosettes*. They differ in the form of their six rays—which are always equal, sometimes simple, ending in a

crenated disk, and at others are simple, subulate, with a more or less spinulose surface, or each divided at the end into two, three, or more linear branches, which are frequently dilated at the end.

In the paper in the 'Annals' above referred to I divided the sponges of this suborder according to their external form; but in the 'Ann. & Mag. Nat. Hist.' 1872, x. p. 134, I proposed to divide them into two groups according to the form of the free spicules; and since then Mr. Carter has shown the importance of the study of the minute free spicules, or *rosettes*.

They may be divided into three sections, as proposed in the 'Annals,' 1872, x. p. 134:—

1. The *rosettes* with the ends of the six rays divided into two, three, four, five, or many branches. Including *Farreadæ*, *Dactylocalyceidæ*, *Aphrocallistidæ*, *Euplectelladæ*, *Corbielladæ*, *Askonematidæ*, and *Crateromorphadæ* (Ann. & Mag. Nat. Hist. 1872, x. p. 134), and *Rossella*, Carter.
2. The *rosettes* with six rays ending in a radiating circular disk. *Carteriadæ*, *Pieronemadæ*, and *Meyerinadæ* (Ann. & Mag. Nat. Hist. 1872, x. p. 134).

Mr. Carter figures many of the *rosettes* of these genera (Ann. & Mag. Nat. Hist. 1873, xii. t. 13 & 15).

3. The *rosettes* subcubical, the rays with three lobes at the end. *Axoidæ*.

I gave the name of *Axos Cliftoni* to Bowerbank's figure (B. S. fig. 197) of the spicule of this sponge; and when Mr. Clifton gave me a fragment of the sponge I described it (Ann. & Mag. Nat. Hist. 1870, vi. p. 272) under the name of *Echino-spongia australis*; but at p. 346 of the same volume I showed that *Axos Cliftoni* should be adopted. Dr. Bowerbank has since figured the specimen from which the fragment was taken by Mr. Clifton under the name of *Dictyocylinurus dentatus* (Proc. Zool. Soc. 1873, p. 321, t. xxix.), without referring to his figure in his work on British sponges.

Suborder III. QUINQUERADIATOSPONGIA.

Sponges with spicules of the quinquerate type in combination with the simple spicules of *Leiospongia*, and frequently having multiradiate spicules and spicular spherules in combination with them, either scattered free in the flesh of the sponge or forming an external bark to it.

The sponges of this suborder present very numerous combinations of spicules; and the five-rayed spicules which form the skeleton of the sponge frequently want the outer end of

the shaft, and the lower end is generally much elongated; and for this reason they have been called four-rayed, trifurcate, or nail-like spicules. They frequently have free, but more or less abundant, regular-shaped many-rayed spicules, or spicular spherules, scattered in their flesh, which are always of a small size, and more or less regular in their shape.

This order consists of the *Sphærospongia* and the family *MacAndrewiadæ* of the 'Annals,' 1872, ix. p. 456.

Section I. Five-rayed or skeleton-spicules often united by siliceous matter; flesh-spicules fusiform, cylindrical, more or less spinose. *Lithistidæ*, Carter (Ann. & Mag. Nat. Hist. 1873, xii. p. 437); *MacAndrewiadæ*, Gray (Ann. & Mag. Nat. Hist. 1872, ix. p. 456).

The sponge formed of superficial sexradiate spicules, which are held together by an amorphous siliceous coat.

Mr. Carter gives an arrangement of the species of the various genera of this group, to which the genera *MacAndrewia* and *Theonella*, Gray, *Corallistes* and *Leiodermatium* of Schmidt, and *Azorica* and *Lithospongitis*, Carter, are referable. In the 'Annals' I placed *MacAndrewiadæ* with the Coralloid sponges having sexradiate spicules; but the examination of more spicules has proved that they belong to the quinquerradiate type, with the habit of the coral-sponges.

Section II. The skeleton-spicules elongate, free from one another, generally forming the circumference of the sponge, sometimes projecting beyond it.

- a. The free flesh-spicules many-rayed, stellate, on the outer surface or inner part of the sarcodæ. *Tethyadæ*, *Donatiadæ*, *Theneadæ*, *Lophurelladæ*, *Casuladæ*. (See *Ecionemia acervus*, and *E. densa*, Bowerbank, Proc. Zool. Soc. 1873, t. xxx. figs. 1-14.)
- b. With spicular spherules forming the outer surface of the sponge. *Geodiadæ*.
- c. The spicular spherules crowded together, and forming the axis and plates on the outer surface of the coral-like sponge, with the sarcodæ and spicules between the two. *Placospongiadæ*.
- d. Without any many-rayed stellate spicules or spicular spherules. *Ancorinadæ*.
- e. Aberrant family, *Chondrilladæ*, with many-rayed stellate flesh-spicules, but without any elongate five-rayed spicules. See *Chondrilla australiensis*, Ann. & Mag. Nat. Hist. 1873, xii. pl. 1. figs. 14-16.